Investigation of long-term stability of precise orbits of altimetry satellites

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Application of precise orbits of altimetry satellites

- Orbit maintenance during the satellite operational phase (orbit manoeuvres), space debris in the post-operational phase
- Quality assessment of altimetry mission performance
- Tests of various background models for precise orbit determination using orbit and altimetry crosssover analysis
- Altimetry mission inter-calibration
- Generation of Radar Altimeter Geophysical Data Records (orbital altitude)
- Generation of mean sea surface height models
- Investigations of global and regional mean sea level changes
- Climate change applications etc.

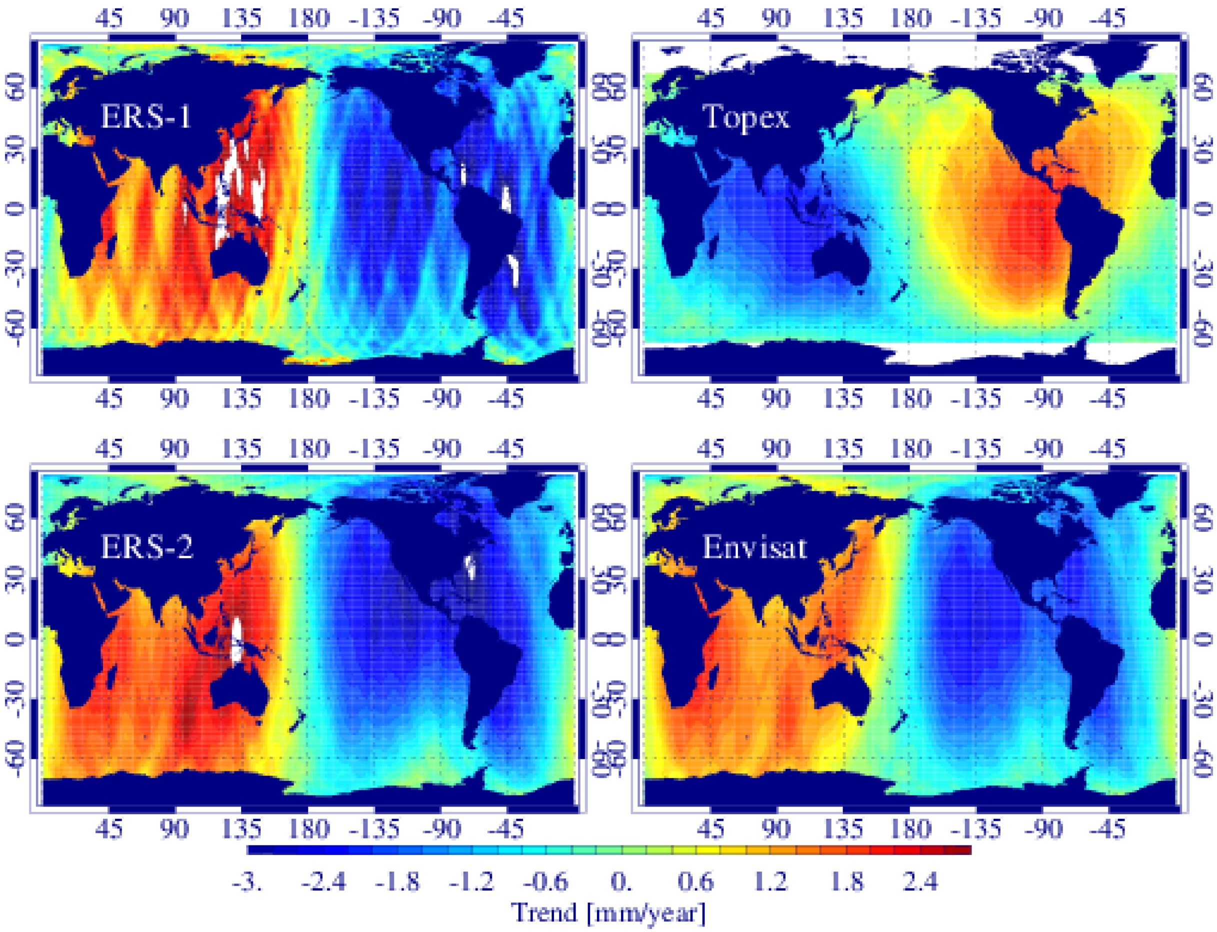
Impact on the long-term stability of precise orbits of altimetry satellites

- A terrestrial reference frame realization (presently used ITRF2008, looking forward to ITRF2013)
- Time-variable Earth gravity field
- Atmosphere-ocean mass variability
- Non-gravitational forces, aging of spacecraft surfaces
- Atmospheric, hydrological loading, non-tidal geocenter motion
- Satellite specific effects, e.g. impact of the South Atlantic Anomaly on Jason-1 DORIS Doppler measurements
- Corrections, range, time, frequency biases of measurements
- Other effects

The main background models for precise orbit determination

Terrestrial Reference Frame	ITRF2008 (Altamimi et al., 2011), SLRF2008 (Pavlis, 2009) and DPOD2008 (Willis, 2011) are used for stations missing in ITRF2008
Polar motion and UT1	IERS EOP 08 C04 (IAU2000A) series with IERS daily and sub-daily corrections
Precession and Nutation model	IERS Conventions (2010)
Gravity field (static)	EIGEN-6S2 (up to n=m=90)
Gravity field (time-variable)	Time series of drift terms, annual and semi-annual variations for n=2-50
Solid Earth tides	IERS Conventions (2010)
Pole tide	IERS Conventions (2010)
Ocean tides	EOT10A (Savcenko and Bosch, 2010), all constituents up to degree and order 50
Atmospheric tides	Biancale and Bode (2006)
Atmospheric gravity	ECMWF 6-hourly fields up to degree and order 50 (Flechtner, 2007)
Third bodies	Sun, Moon, Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto (DE-421) (Folkner et al., 2009)

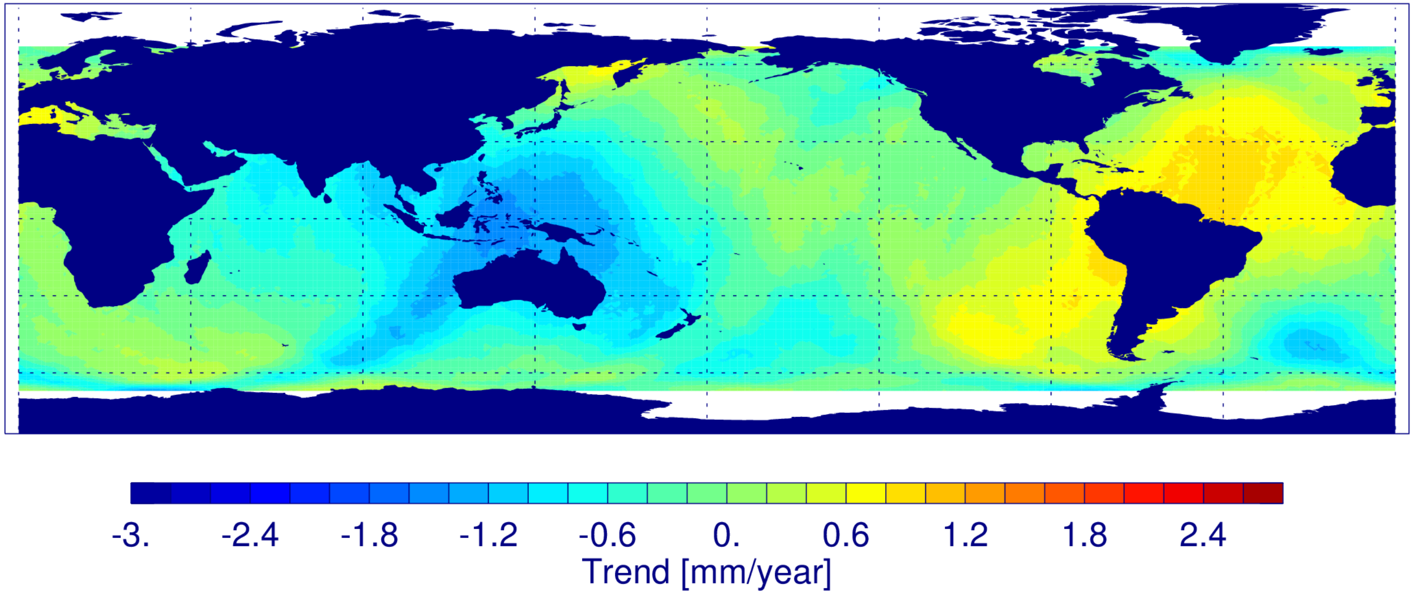
Impact of the drift terms of a time variable geopotential model on the regional mean sea level trends (case ERS-1, ERS-2, TOPEX/Poseidon, Envisat)



Up to ±3 mm/yr East/West differences in the regional mean sea level trends, obtained with satellite orbits computed using EIGEN-GL04S and EIGEN-6S geopotential models that differ mainly by presense of geopotential drift terms in EIGEN-6S model

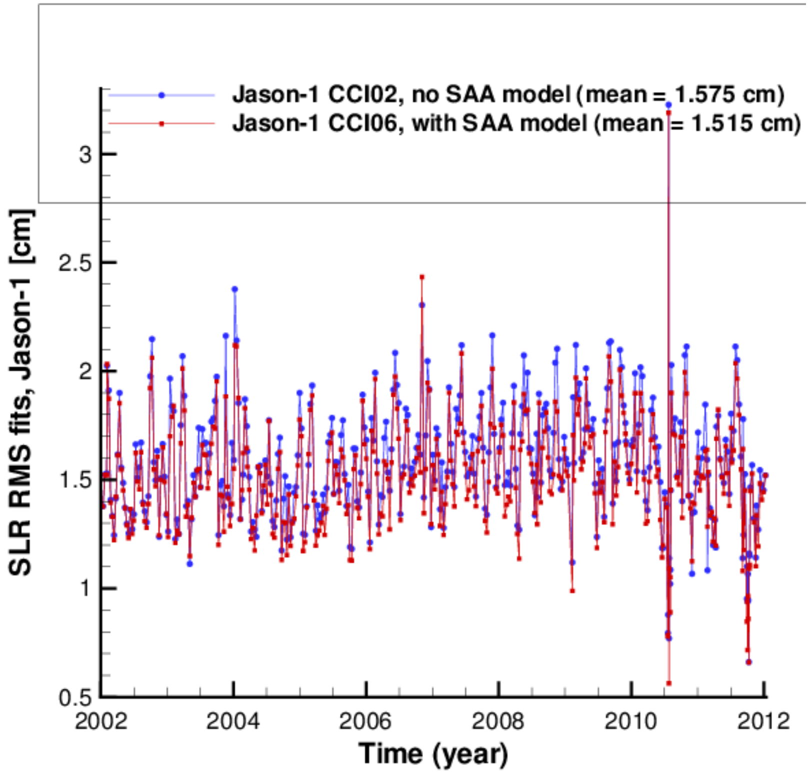
Rudenko et al., Advances in Space Research, 54 (2014) 92-118

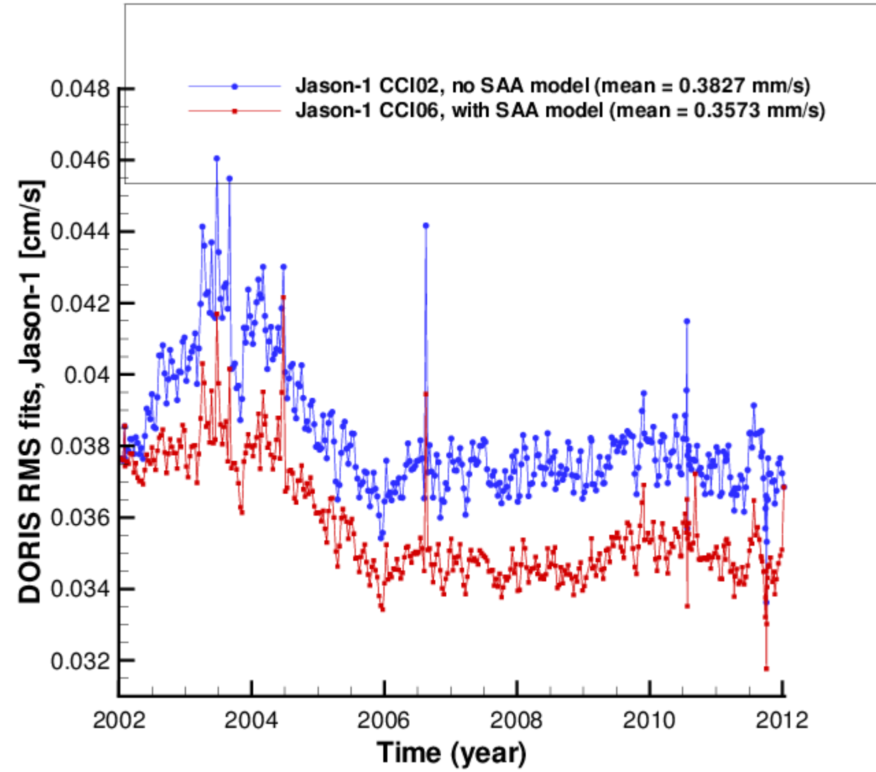
Impact of the drift terms of time variable geopotential model on the regional mean sea level trends: case Jason-1



Regional mean sea level trends differences computed using Jason-1 orbits derived by using EIGEN-GL04S and EIGEN-6S2 geopotential models – the pattern for Jason-1 is similar to that one of TOPEX/Poseidon

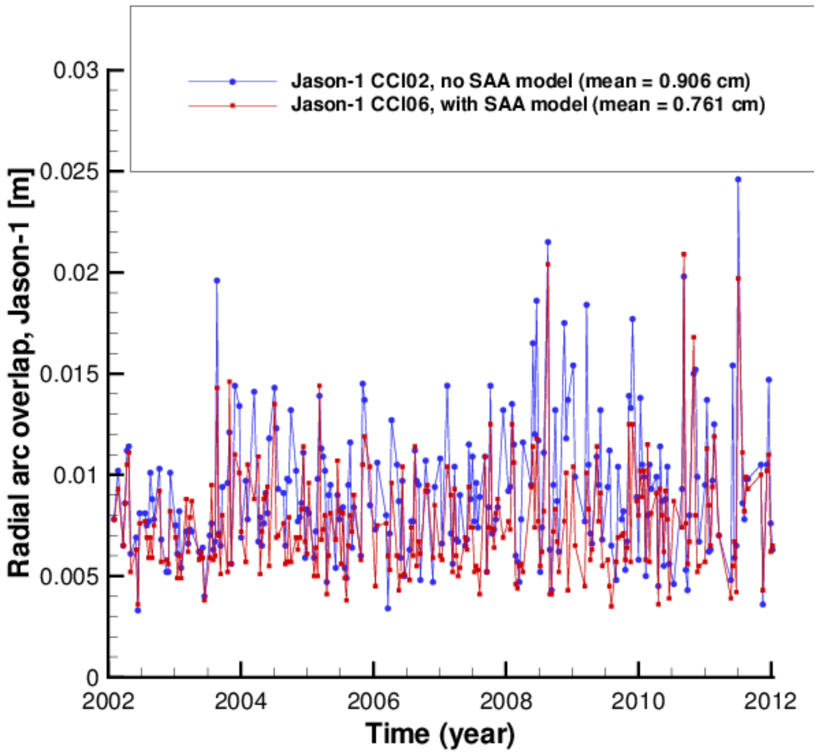
Satellite specific corrections: impact of the South Atlantic Anomaly on Jason-1 SLR and DORIS RMS fits

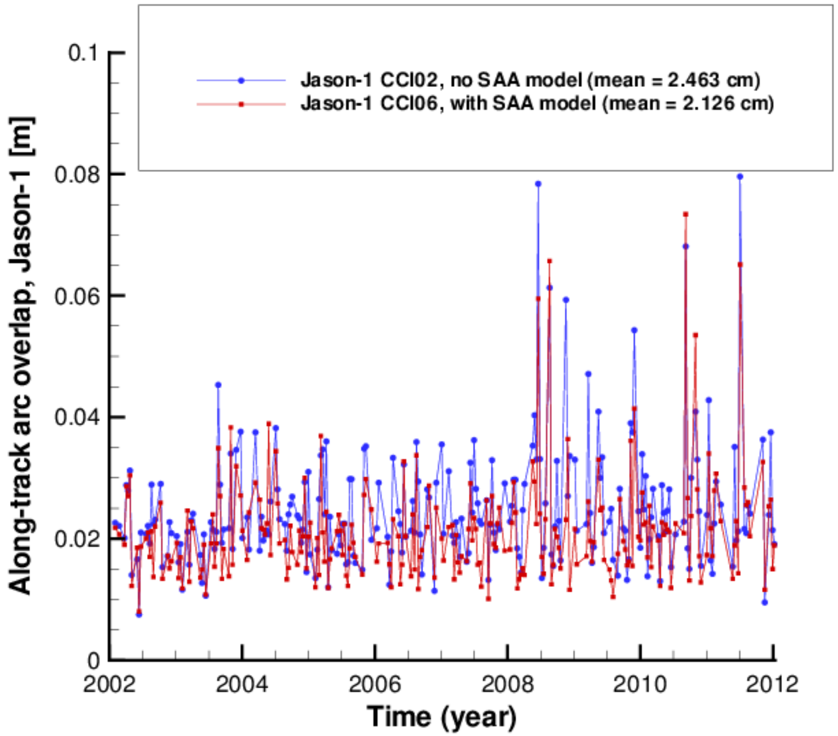




Use of the corrective model (Lemoine et al., 2006) for Jason-1 DORIS Doppler data for the South Atlantic Anomaly reduces the mean value of SLR RMS from 1.58 to 1.52 cm, i.e. by 0.06 cm (3.8%) and of DORIS RMS fits from 0.383 to 0.357 mm/s, i.e. by 0.026 mm/s (6.6%)

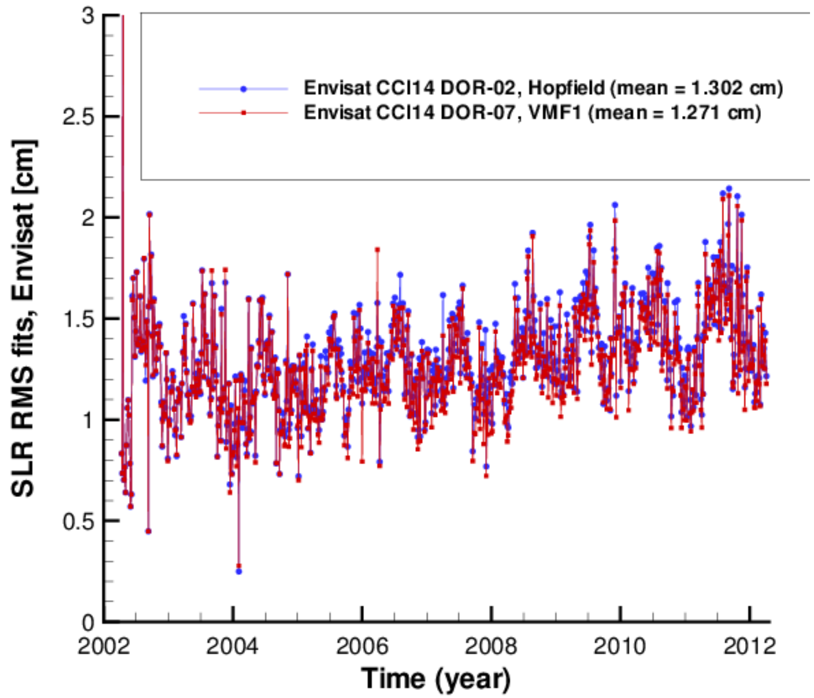
Impact of the South Atlantic Anomaly on Jason-1 two-day orbital arc overlaps

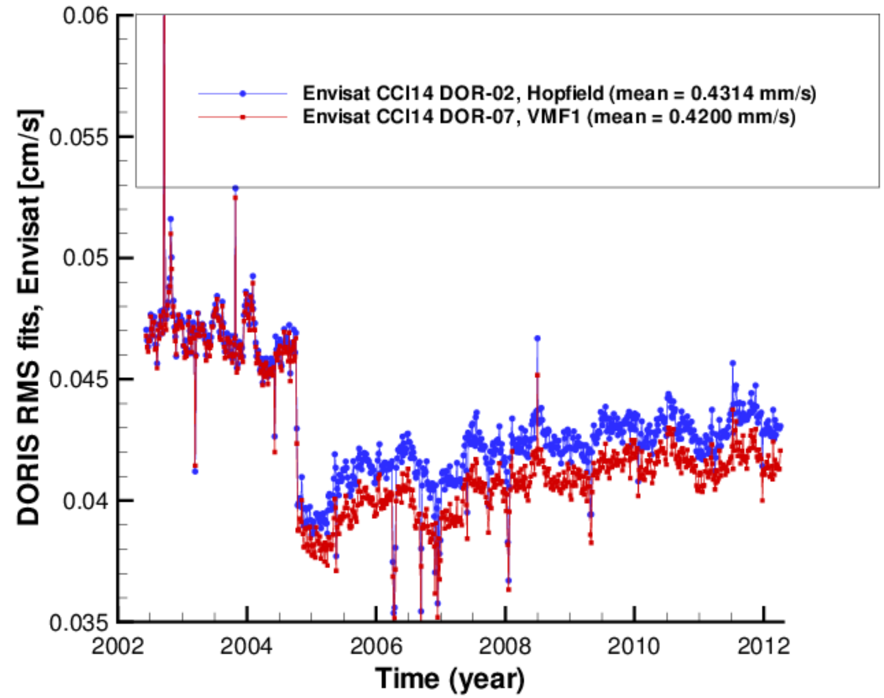




Reduction of the mean values of 2-day orbital arc overlaps when using the corrective model for Jason-1 DORIS Doppler data for the South Atlantic Anomaly: radial – from 0.91 to 0.76 cm (by 16.0%), cross-track – from 4.71 to 4.35 cm (by 7.6%) and along-track – from 2.46 to 2.13 cm (by 13.7%)

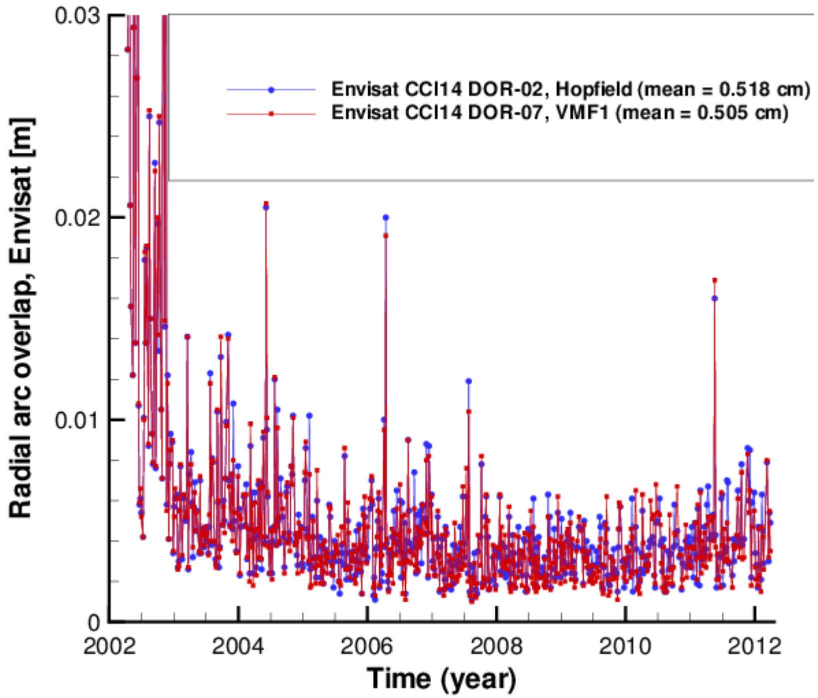
Impact of a tropospheric refraction model (Vienna Mapping Function 1 and Hopfield model) for DORIS data on Envisat SLR and DORIS fits

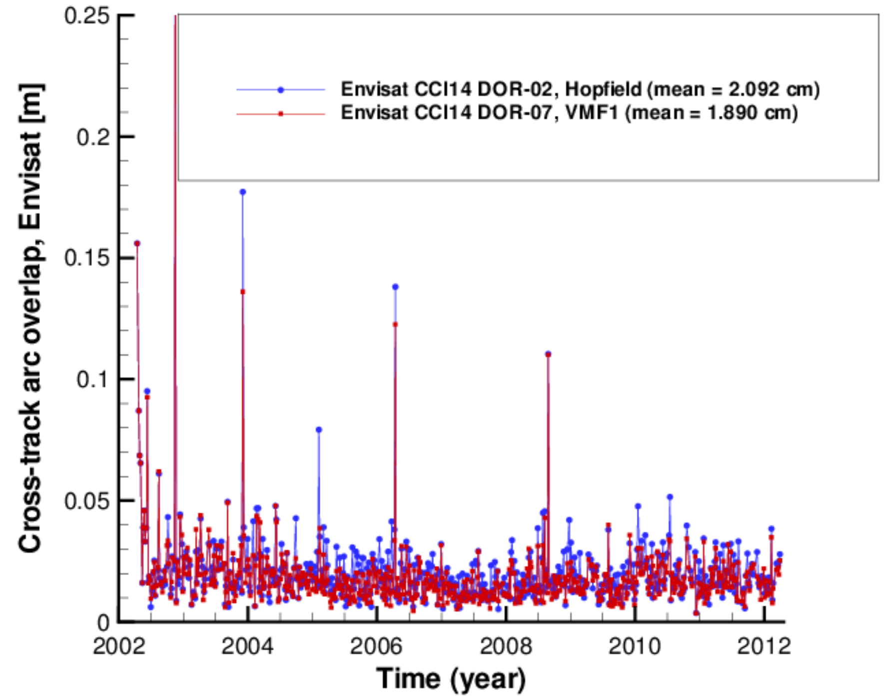




Use of Vienna Mapping Function 1 (Boehm et al., 2006) reduces Envisat mean values of SLR RMS fits from 1.30 to 1.27 cm, i.e. by 0.03 cm (2.4%), and of DORIS RMS fits from 0.431 to 0.420 mm/s, i.e. by 0.011 mm/s (2.6%), as compared to the values obtained using Hopfield model

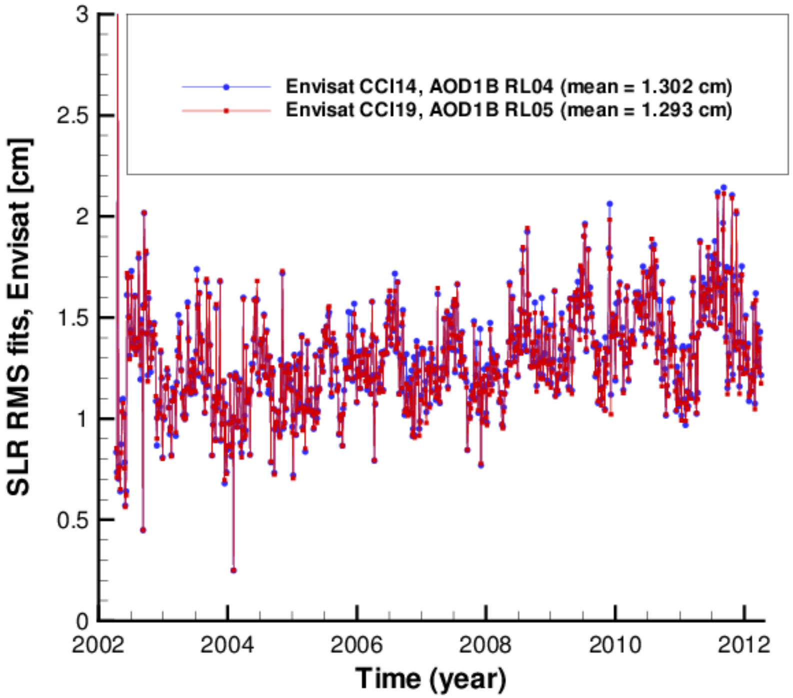
Impact of a tropospheric refraction model (Vienna Mapping Function 1 versus Hopfield model) for DORIS data on Envisat two-day arc overlaps

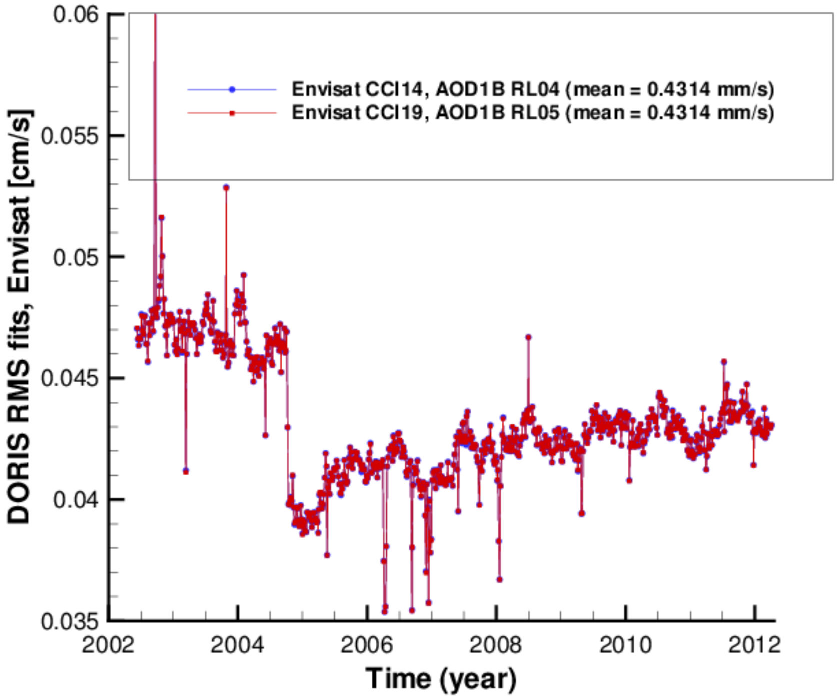




Reduction of the mean values using VMF1 instead of Hopfield model:
radial arc overlaps from 0.518 to 0.505 cm, i.e. by 0.013 cm (2.5%),
cross-track arc overlaps from 2.092 to 1.890 cm, i.e. by 0.202 cm (9.7%),
along-track arc overlaps from 2.158 to 2.099 cm, i.e. by 0.059 (2.7%)

Impact of atmosphere-ocean dealiasing products (AOD1B RL05 versus RL04) on SLR and DORIS RMS fits: case Envisat



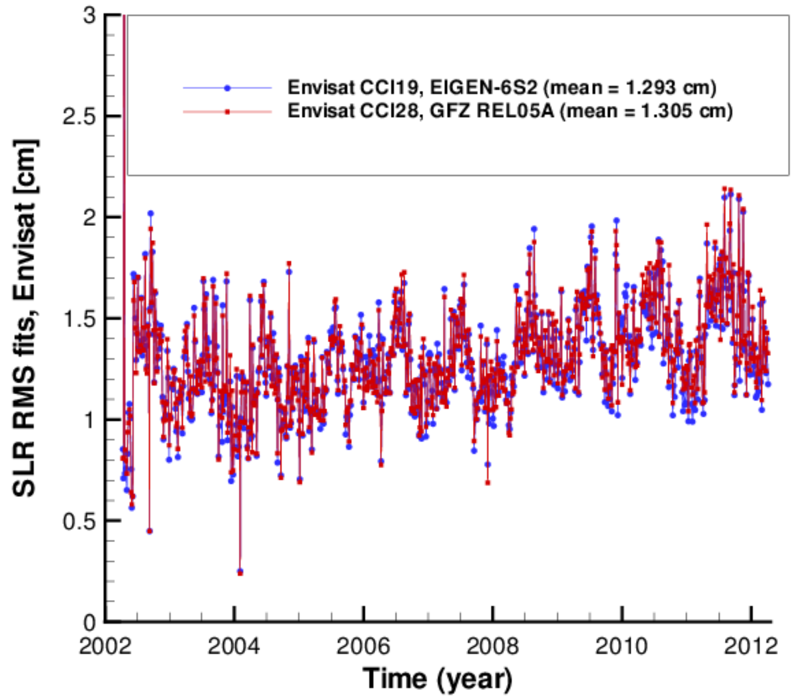


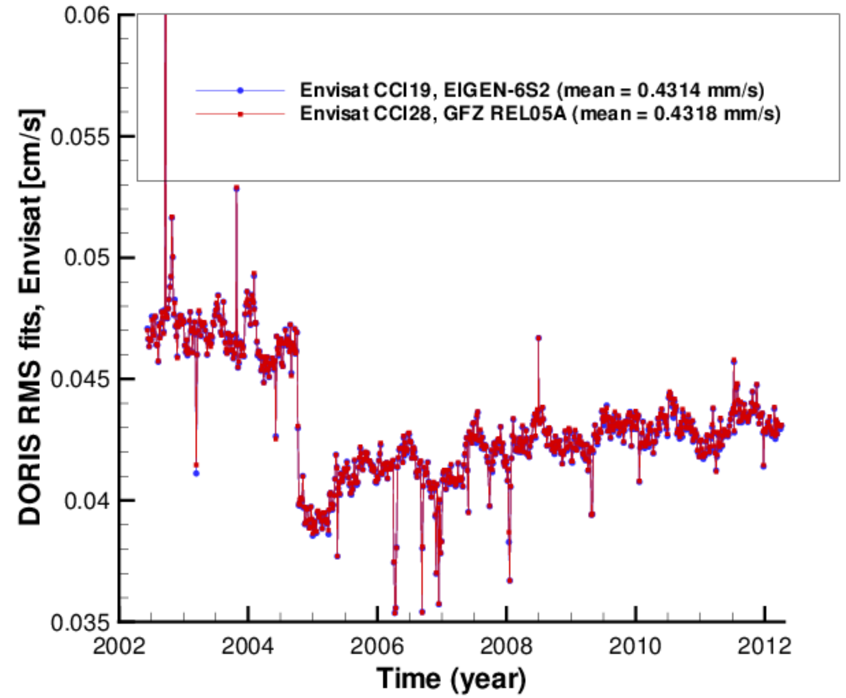
Using AOD1B RL05 instead of AOD1B RL04 reduces the mean value of Envisat SLR RMS fits from 1.302 to 1.293 cm, i.e. by 0.009 cm (0.6%), and has almost no effect on DORIS RMS fits.

A test on using daily gravity field solutions interpolated from monthly GFZ REL05A solutions and EIGEN-6S2 model: model description

Parameter	EIGEN-6S2	GFZ REL05A
Static model, max n,m	EIGEN-6S2, n=m=260	EIGEN-6C, n=m=360
Model (solution) reference epoch	Coefficient specific	01.01.2003
Geopotential truncation level	90	90
Time coverage	1950-2050	01.04.2002 - 30.06.2014
C(2,0)-S(2,2)	A yearly scalar at 1985-2012, constant outside	C(2,0) replaced by values from Cheng et al. (2011)
C(2,0)-S(2,2) drift terms	A yearly scalar at 1985-2012, 0.0 outside	Centered differences 7 point Newton interpolation
C(3,0)-S(50,50) drift terms	A yearly scalar at 2003-2012, 0.0 outside	Centered differences 7 point Newton interpolation
C(51,0)-S(60,60) drift terms	0.0	Centered differences 7 point Newton interpolation
Annual and semi-annual variations	For degree and order 2-50 terms	For degree and order 2-60 terms, centered differences 7 point Newton interpolation

A test on using daily gravity field solutions interpolated from monthly GFZ REL05A solutions and EIGEN-6S2 model: SLR and DORIS RMS (case Envisat)





EIGEN-6S2 model provides 0.9% smaller mean value of SLR RMS fits and 0.1% smaller mean value of DORIS RMS fits than daily gravity field solutions interpolated from monthly GFZ REL05A solutions

Conclusions

- Ignoring time variability of the Earth gravity field leads to an error up to ±3 mm/yr in the regional mean sea level trends
- Contemporary time-variable Earth mean gravity field models, like e.g. EIGEN-6S2, seem to provide presently better quality of altimetry satellite orbits than daily gravity field solutions interpolated from monthly solutions (noise level in monthly solutions), the work is in progress
- Satellite specific models, like e.g. a corrective model (Lemoine et al., 2006) for Jason-1 DORIS Doppler data for South Atlantic Anomaly, are important. This model notably improves Jason-1 orbit quality
- A tropospheric refraction model for DORIS data based on Vienna Mapping Function 1 performs better than Hopfield model
- Release 5 of the GFZ AOD1B atmosphere-ocean dealiasing product improves SLR RMS fits, as compared to release 4 of this product

Acknowledgments

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